LEPA AND SPRAY IRRIGATION FOR GRAIN CROPS[a]

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ABSTRACT: Two low energy precision application (LEPA) sprinkler methods (double-ended socks and bubblers) and two spray sprinkler methods (low-elevation spray application and overhead spray) were used to irrigate corn, grain sorghum, and winter wheat in the Southern High Plains. For full or 100% irrigation, sufficient 25-mm applications were applied to maintain soil water at non-yield-limiting levels determined in earlier research with the three crops. Deficit-irrigated treatments were irrigated on the same days as the control treatment in 25 or 33% increments of the fully irrigated amount. Irrigation water was applied to or above alternate furrows with a three-span lateral move irrigation system. Corn and sorghum were grown on beds and furrows with all furrows diked, and wheat was flat-planted without basin tillage. Grain yields increased significantly with irrigation amount ($p \leq 0.05$) for all crops during all years. With full irrigation, grain yields varied little among the sprinkler methods, and yields averaged 13.5, 8.9, and 4.6 Mg/ha for corn, sorghum, and wheat, respectively. With the 25 and 50% deficit irrigation amounts, sorghum yields with LEPA irrigation were 1.1 Mg/ha larger than with the two spray methods. For 75% irrigation of sorghum and for deficit irrigation of the other two crops, there was little yield difference between the LEPA and spray sprinkler methods. Grain yields were significantly correlated with seasonal water use with regression coefficients of 2.89, 1.84, and 0.915 kg/m^3 for corn, sorghum, and wheat, respectively.

INTRODUCTION

In the Southern High Plains, a major transition from furrow to sprinkler irrigation has been underway since the late 1950s (Musick et al. 1990). The impact sprinklers initially used on center-pivot irrigation systems have largely been replaced by spray heads having higher application efficiencies (Musick et al. 1988). More recently, the low energy precision application (LEPA) sprinkler method was developed by Lyle and Bordovsky (1981) to increase application efficiencies in the 95–98% range. In on-farm evaluations with equal amounts of water, Fipps and New (1990) measured larger crop yields with LEPA than with other sprinkler methods (type of sprinkler method not reported).

When compared with spray irrigation, LEPA eliminates droplet evaporation and drift and crop canopy evaporation and reduces soil evaporation, particularly when irrigating alternate furrows. For 123 center-pivot irrigation systems equipped with spray heads, Musick et al. (1988) reported an average application efficiency of 85% based on the sprinkler catch in oil cans. For LEPA irrigation, Lyle and Bordovsky (1983) measured an application efficiency of 99% with catch containers when averaged over 24 irrigations. Similarly, Schneider and Howell (1990) reported LEPA application efficiencies of 96–98% measured with 9-m^2 weighing lysimeters.

Although the reported application efficiencies for LEPA irrigation are 10% or more larger than for spray irrigation, the on-farm efficiency of the two sprinkler methods may be nearly equal. Runoff from high-flow LEPA devices may either redistribute water within the field or leave the field completely. For example, Buchleiter (1992) measured runoff amounts exceeding 30 and 55% of the applied water on 3 and 8% slopes, respectively. Spurgeon et al. (1995) compared the LEPA bubble and flat (in-canopy) spray sprinkler methods on a Ulysses silt loam soil with soil surface modification and slopes ranging from 0.3 to 6.9%. The linear regression model developed from their data predicted equal grain yields by both sprinkler methods with zero slope but larger yield reductions due to slope for the LEPA method than the flat spray method.

Recent studies indicate smaller evaporation losses from sprinkler and spray irrigation than suggested by the earlier work of Christiansen (1942) and Frost and Schwalen (1955). In a laboratory study, Kincaid and Longley (1989) found that the evaporation rate of 1.0-mm-diameter droplets subjected to the high evaporative environment of 31°C and 22% relative humidity did not exceed 1% of the mass per second. Solomon et al. (1985) showed that the average droplet size from serrated spray plates exceeds 1.0 mm. With in-air times <1 s, droplet evaporation with serrated spray plates would then be expected to be 2% or less. This estimate is supported by Kohl et al. (1987) who measured low-pressure sprinkler losses of 0.5–1.4% from smooth spray plates and 0.4–0.5% from coarse, serrated spray plates. Modeling studies by Thompson et al. (1993, 1997) showed a total droplet evaporation loss of 3% from a solid set sprinkler system and 1% from a moving lateral irrigation system. For a mature corn canopy, Tolk et al. (1995) showed that, after accounting for microclimate modification and transpiration suppression due to evaporation of canopy-intercepted water, net canopy evaporation losses ranged from 5.1 to 7.1%.

Although considerable data are available for both the LEPA and spray sprinkler methods, field studies comparing LEPA with high-efficiency spray irrigation are limited. Howell and Phene (1983) measured the lint yield of cotton irrigated with trickle drag lines similar to LEPA and overhead spray. Lint yields from a single, fully-irrigated crop were 613 and 688 kg/ha for the trickle drag lines and spray, respectively. In the field study of Spurgeon et al. (1995), the yield reduction due to slope with fully irrigated corn was 1.48 Mg/ha/%slope with the LEPA bubble method and 0.73 Mg/ha/%slope with the flat (in-canopy) spray method. The original LEPA evaluation (Lyle and Bordovsky 1983) was a comparison between LEPA and impact sprinklers and did not include spray irrigation. In their 6-year summary of LEPA irrigation in Texas, Fipps and New (1990) did not list the type of conventional sprinkler methods used in the center-pivot comparisons. Their LEPA devices were located in the span nearest the outer span, and Fangmeier et al. (1990) showed that outer spans have better uniformity than the interior ones.

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